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PAMPHLET SERIES,
No. 54.

IMPERIAL

DEPARTMENT OF AGRICULTURE

FOR THE WEST INDIES.

FUNGUS DISEASES OF CACAO

AND

SANITATION OF CACAO ORCHARDS

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ISSUED BY THE COMMISSIONER OF AGRICULTURE.

1908.

PREFACE.

The following pages contain the substance of a paper read before the Seventh West Indian Agricultural Conference held at Barbados in January last, on the fungus diseases of cacao and the sanitation of cacao orchards, by Mr. F. A. Stockdale, B.A., F.L.S., Mycologist and Agricultural Lecturer on the staff of this Department. The full paper has been published in the *West Indian Bulletin*, Vol. IX, No. 2.

Cacao comes second in importance to sugar among the products of the West Indies, the exports in 1906-7 being valued at nearly £1,400,000. It forms practically the sole crop of Grenada, and in Trinidad the value of the cacao crop is approximately double that of the sugar. It is also an important industry in Jamaica, St. Lucia, and Dominica, while at St. Vincent it is one of the crops that have received special attention in connexion with the Land Settlement Scheme.

Fungus diseases of cacao have, from time to time, been the subject of careful investigation by officers of the Imperial Department of Agriculture, and remedial measures have been given careful trial. Recently Mr. O. W. Barrett, of the United States Department of Agriculture, was specially engaged by the Government of Trinidad for a period of five months in investigating the diseases affecting cacao in that colony.

In this pamphlet, brief descriptions of the principal diseases are given, and remedial measures that have proved to be most successful in dealing with these diseases are carefully described. It would appear that the fungus diseases of cacao are quite amenable to treatment, and as the recommendations put forward are simple and practical in character, there should be no difficulty in carrying them out.

The sanitation of cacao orchards is dealt with in the concluding part of the pamphlet, and the principal points for consideration toward maintaining the health of the trees and preventing disease are briefly indicated.

It is estimated that considerably increased yields could be obtained on the majority of cacao cultivations by paying special attention to insect pests and fungus diseases, and to the important matters here grouped together under the head of sanitation of cacao orchards.

It is therefore hoped that the contents of this pamphlet will receive the careful attention of cacao planters.

J. P. D'ALBUQUERQUE,
For Commissioner of Agriculture
for the West Indies.

Barbados,
July 31, 1908.

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INTRODUCTION.

Fungus diseases of cacao have from time to time occasioned considerable losses, and during the last ten years have been under careful investigation. It is proposed to present a complete review of these diseases, together with information that has been obtained respecting their treatment and of the new diseases that have come under observation. Particular attention will also be drawn to the sanitation of cacao orchards, in the hope that assistance may be rendered to cultivators towards reducing and preventing those losses that are frequently overlooked and sometimes, it is feared, totally disregarded.

In old records of the West Indies, reference was made to 'blights' that affected the cacao in different localities, but it was not until 1898 that attention was specially drawn to specific fungus diseases. In that year, some diseased pods were brought under observation in Trinidad and were investigated by the Botanical Department of that colony and by authorities at Kew. A year or so later, investigations were commenced by Mr. Howard, (then Mycologist attached to the staff of the Imperial Department of Agriculture) of fungus diseases of cacao at Grenada. Since then, observations have been continued by this Department by Mr. Lewton-Brain and, for the past three years by myself in Dominica, St. Lucia, St. Vincent, and elsewhere. Considerable information in respect to life-histories

of the fungi and to remedial treatments of the diseases has been acquired, and it has been satisfactorily demonstrated during the past few years that practically all the different diseases are amenable to treatment. Reliable data in respect to the success of various remedial measures have been forthcoming. It has been shown by the experiment plots, established by the Imperial Department of Agriculture in various districts in the different West India Islands, where diseases had been allowed to develop almost to a maximum, that such diseases may rapidly be reduced to a minimum by careful treatment. The increase in crops thereby obtained, moreover, allowed of a sufficiently good margin of profit over the increased expenditure incurred in cultural operations to commend such treatment for the consideration of all cacao cultivators.

The most important of the cacao districts of the West Indies have been surveyed for the purpose of obtaining information in respect to the occurrence and damage incurred by the different fungus diseases, and remedial measures have been given careful trial. Observations have recently been made in Dominica, St. Lucia, and St. Vincent, while cacao at the Botanic Station, Grenada, and in some districts of Trinidad has also been inspected. During last year, Mr. O. W. Barrett was engaged in studies in Trinidad and issued several reports.

It is proposed to group the diseases of cacao under subheads : (1) Root disease, (2) Stem diseases, and (3) Pod diseases, while at the end of the article, notes will be given on general sanitary observations for cacao plantations.

ROOT DISEASE.

Attention was first called to a root disease of cacao in the West Indies by Barber in his report on the failure of the Dominica cacao crop of 1892-3. It was recorded to affect also mangos, oranges, coffee, and bread-fruit. In 1901, Howard investigated a root disease in certain districts of Grenada, and recorded that a similar disease affected nutmegs and many other cultivated trees. The opinion was also expressed that the Dominica and Grenada diseases might be identical. A similar disease was also known to occur in cacao and coffee cultivation in Jamaica.

Later in the same year, specimens of cacao trees affected with root disease from Dominica were examined by Howard in the mycological laboratory of this Department, and it was found that the roots had been affected by a fungus that closely resembled that observed in the Grenada cacao root disease.

Recently, investigations have been made into the occurrence of root disease of cacao in the various cacao-producing districts of these islands, and it has been found that a disease occurs fairly commonly in many parts of Grenada, Dominica, and St. Lucia. Remedial measures have been given careful trial, and it has been found that this disease is quite amenable to treatment if taken during its early stages. Examination has been commenced of the fungus that causes this disease, but in spite of the frequent occurrence of the disease, no fructifications have yet been found in the field nor have they been produced in the laboratory.

Clamp connexions characteristic of the Basidiomycetes have sometimes been observed in the fungal hyphae but opinion as to identification of the fungus must be deferred until further investigations have been completed and until fructifications have been obtained.

A root disease of coffee and pois-doux in Guadeloupe has been described by Delacroix.

OCCURRENCE OF ROOT DISEASE.

A careful description of the disease known in Grenada, Dominica, and St. Lucia may be of interest, while the remedial measures that have been found to be successful cannot fail to attract attention. This disease is sometimes alluded to in these islands as 'canker of the root.'

SYMPTOMS OF ROOT DISEASE.

Trees affected with root disease present a sickly appearance. The leaves become small and assume a yellowish hue, while the branches begin to wither from the tips—the leaves wilting. These branches eventually die off, and subsequently the whole tree may be killed. Trees are rarely killed off singly but usually in patches. These patches of dead trees, unless something is done, increase in size, and it has been observed in Dominica when the disease has been neglected, that areas of nearly an acre in extent have been destroyed.

It has frequently been noticed—though this is not always the case—that these patches, when they are quite small, are circumscribed by the spread of roots from trees that have been used for shade.

Pois-doux, bread-fruit, bread nut, mango, pomme rose, and avocado pear, which are dead or dying, have been commonly observed in the centre of a diseased area of cacao, and it has been suggested that the fungus attacks the dead or dying roots of these trees and then affects the young roots of the cacao. It has undoubtedly been established that the fungus under consideration may spread from affected roots of pois-doux or bread-fruit, and it has been observed to spread for a considerable distance along a pois-doux wind-break from tree to tree.

In Dominica, it has been found that cacao has become affected where none of the above-mentioned trees were present, and it was difficult, owing to the length of time that elapsed since the disease first appeared and when investigations were made, to establish clearly at what spot the disease commenced. On this estate, the soil of which appeared to be of uniform quality, a patch of fifteen to twenty trees was killed out, and then at a distance of say about 100 yards another patch was destroyed. The intervening trees were quite healthy and their roots did not in any manner appear to be affected. In this island it has also been found that root disease is fairly prevalent in cacao fields planted in recently cleared forest land, but it is suspected that more than one species of fungi may be interested in this trouble, and that the disease may have originated from the fungi found on the decaying logs lying about the fields.

If the roots of a diseased cacao tree are laid bare and carefully examined, it will be found that many of them are black and decayed. Careful

observation will reveal the white strands of a fungus mycelium attached to these roots, and passing into the bark and into the tissues of the root. If, however, the bark of diseased roots is peeled off, a white web of fungus mycelium—usually arranged in somewhat star-like masses—will be found between the bark and the wood. This is a typical sign of the disease and is always to be observed in the larger diseased roots.

The mycelium is at first white, then grey, and finally assumes a light-brown colour. From this mycelium, hyphae may be followed into the deeper woody tissues of the roots, and almost a white rot takes place. During the growth of the mycelium, the woody tissues of the root become softer and lighter, while, frequently, dark-coloured streaks, caused by the accumulation of some gummaceous substance, may be seen distributed throughout the root. Eventually, the water in the soil aids a wet rot, and the diseased roots, except the bark, become quite soft and rotten.

In the younger roots, the typical mycelial threads between the bark and the wood is not apparent, but there is usually a brown discoloration of the inner bark tissues due to gummy substances being formed through the attack of the fungal threads.

When the fungus has invaded all the principal roots or has spread upwards and encircled the lower portion of the stem, the tree dies. The disease, however, is not a rapid one, and when taken in the early stages has been found to be quite amenable to treatment.

SPREAD OF ROOT DISEASE.

The spread of the disease is by underground mycelium. It frequently commences, as above stated, from pois-doux, bread-fruit or other trees, and it is seldom that it can be detected in its very initial stages, for when it is noticed, several cacao trees—usually in a circle—have been infected.

REMEDIAL MEASURES FOR ROOT DISEASE.

DESTRUCTION OF ALL INFECTED TREES.

Whenever pois-doux, bread-fruit, bread nut, mango, pomme rose, or avocado pear trees are noticed in a cacao plantation to be dying, they should immediately be taken out and burned. Particular care should be taken thoroughly to extract as many as possible of their roots and destroy them. Trenches should also be dug, to cut off the roots of the cacao tree from those of the trees in the infected spots. It is frequently advised that bread-fruit, bread nut, and avocado pear trees should not be planted amongst cacao in new plantations, and when any such trees have to be removed from old plantations care should be taken to extract their roots. The pois-doux is not very often attacked, and, therefore, may be used for wind-belts; but these trees should be carefully watched, for it has been observed that this disease has often commenced among cacao from dead pois-doux.

ISOLATION OF AFFECTED AREAS.

When an area of cacao is affected, it should be isolated from the remainder of the plantation by

digging a trench, about 2 feet deep and 18 inches wide, around the diseased trees. This encircling trench should be connected with the general drainage system to prevent the lodgment of water, and care should be taken to include all the unhealthy trees in the circumscribed area, and to throw the earth from the trench into that portion that has been cut off. The surrounding healthy trees should be kept under observation for some time in order to ascertain whether isolation has been complete. If it has not, a further trench encircling a larger area must be dug.

TREATMENT OF TREES IN ISOLATED AREAS.

All the trees in the affected and isolated area must now be carefully examined. The most badly diseased ones should be taken out, their roots extracted, and the whole burned. Others less badly affected should have the soil removed from their principal roots, and the roots laid bare. The diseased roots should be cut off, and the diseased parts removed and burned. A good application of lime—say 5 lb.—should then be given in the holes that have been made around the trees, while laying bare the roots, and turning back the soil. If a large number of roots have had to be cut off, a good heavy pruning should be given to the tree, in order that it may not suffer from excessive transpiration while possessing a reduced root area.

The whole of the isolated area, after the trees have been separately examined and treated, should then be properly forked, and a good application of quick lime—at the rate of about 10 lb. per tree—

should be broadcasted. After a time, applications of pen manure and mulchings should be given, and in the following year another general application of lime—at the rate of about 3 to 4 lb. per tree should be made. After the first general thorough forking, it is advisable that further forking should not be given for some years unless the trees are falling back, the land being kept in good tilth by heavy mulchings of grass and leaves. Forking always causes wounds to the roots, and if fungus is present in the soil, it is a means of spreading the disease.

RESULTS OBTAINED.

Planters who have followed these remedial measures in Dominica and St. Lucia have saved considerable numbers of trees, and it has clearly been demonstrated that this disease, if it is taken sufficiently early may be successfully treated.

CANKER.

This disease of the bark of stem and branches of the cacao tree first came into prominence in Ceylon, where it was investigated by Willis, and later more fully by Carruthers about 1897. Attention was called to a disease in cacao in Trinidad by Hart, who in 1898 sent specimens of a fungus on pods of cacao to Kew for identification. Subsequently another fungus was found by Hart destroying the bark of cacao trees in Trinidad and was forwarded to Kew. In 1901, Howard investigated a 'canker'

disease of cacao in Grenada, and the fungus found was referred by Massee to *Nectria theobromae*, n. sp., and stated to be identical with a fungus sent some time previously by Hart from Trinidad. Howard also obtained another fungus in Grenada from cankered trees, and this was named by Massee, *Calonectria flavida*, n. sp. This fungus was subsequently noticed in Dominica and also was noted in Trinidad by Hart. A species of *Fusarium* is also associated, but is supposed to be saprophytic.

Inoculation experiments conducted by Howard in Grenada by introducing ripe spores into wounds in cacao trees showed that both *Nectria theobromae* and *Calonectria flavida* were parasitic in habit, for in each case distinct infection was produced.

It has been found that *Nectria theobromae* and *Calonectria flavida* may occur together in the diseased area, while at other times they may occur alone. In Dominica, it was supposed at first that the last mentioned was alone responsible for the canker in cacao, but recently *Nectria theobromae* has been found there, as well as in St. Lucia.

In October 1906, a species of *Lasiodiplodia* was forwarded to this Department by Hart from Trinidad for examination, and a similar fungus has been recorded from Brazil and San Domingo. Last year (1907) this fungus was found associated with *Nectria theobromae* in cankered areas on cacao trees in Grenada, and recently Barrett has reported that it is common throughout Trinidad and may be responsible for a considerable quantity of the canker present in cacao plantations.

It will therefore be advisable that a brief review of our knowledge of canker in the West Indies as caused by *Nectria* or *Calonectria* should be given, and the remedial measures that have been found to be successful, indicated.

OCCURRENCE OF CANKER.

This disease is met with in Trinidad, Grenada, Dominica, and St. Lucia, and I have seen a few cases in St. Vincent and Jamaica.

SYMPTOMS OF CANKER.

By the keen observer, canker may be detected in its early stages. The bark of the affected areas presents a peculiar dry, greyish-brown appearance. The best time to look for these areas would appear to be in the dry season immediately after a shower of rain. These greyish brown areas do not dry as quickly as the unaffected portions of the bark, and the limits of the affected portions may thus generally be ascertained. If the bark is cut by a knife at these points, it will be found to be slightly discoloured, particularly in the outer layers. Later as the disease increases, the bark of these patches on being cut, presents a deep claret colouration. It is moist and soft to the touch, and if it is removed it will be found that the outermost layers of the woody tissues are affected.

BLEEDING STAGE.

Subsequently, these affected areas split or crack, and allow a brownish-red gummy fluid to ooze out. When this gum dries, it gives a dark rusty appear-

ance to the bark. This is known as the 'bleeding stage,' and the disease is now well established.

FLOWERING STAGE IN DOMINICA.

In Dominica, cacao plants are often noticed that produce an abnormal number of flowers which never set fruit. This flowering may continue throughout the whole year, and is known as the 'flowering disease.' This, in Dominica, is generally one of the first symptoms of canker, for it has recently been demonstrated that such trees always eventually develop the disease. Whether this condition may satisfactorily be overcome by careful and high cultivation has yet to be demonstrated. A similar extraordinary flowering has been observed in St. Lucia, but it has not yet been satisfactorily ascertained whether it is common.

It has been observed that canker is generally to be noticed more frequently among old trees, and it has rarely been observed on very young ones. A canker on trees six years old has recently been recorded from Dominica, which differs slightly from that above described in certain characteristics.

EFFECTS OF CANKER.

Canker may affect a branch or a stem, and frequently several spots may be noticed on the same tree. When these diseased areas are numerous, the leaves become small and assume a yellowish hue. The spread of the disease in the bark varies considerably. It may spread quickly round the tree, or may extend in all directions. Branches frequently die off through having become 'ringed,' and

not uncommonly whole trees, particularly when the diseased area is near the surface of the ground, are killed. Undoubtedly, canker appears to be the more serious when it attacks the stem at about the level of the ground.

Frequently, under badly diseased cankered areas the woody tissues assume a dark-brown colour. Howard states that the tissues are penetrated by the mycelium of the fungus, but subsequent investigation would suggest that the fungal hyphae penetrate to but a slight distance in the woody tissues. It would also appear to be questionable whether they are directly parasitic on the wood.

FRUCTIFICATIONS OF CANKER FUNGI.

In the rainy season the fructifications of the two fungi (*Nectria theobromae* and *Calonectria flavida*) may generally be found. White pustules make their appearance through minute cracks in the diseased bark and large numbers of conidia are produced, while subsequently colonies of perithecia make their appearance. These may be yellow (belonging to *Calonectria*) or red (belonging to *Nectria*), and contain the asci containing the ascospores. An exact knowledge of the life-histories of these fungi is not yet complete, and investigations will be continued.

Ripe ascospores have been found to produce infection when introduced into wounds in the cacao tree, and it is generally held that these fungi are wound parasites.

SPREAD OF CANKER.

As the fungi that are associated with this disease are held to be wound parasites, particular care should be taken with all wounds, both those made in pruning and gathering the crop, and accidental ones. If attention be given to all wounds, the spread of canker can rapidly be checked. Conditions of dense shade and abundance of moisture favour the spread of the disease, and should receive attention when remedial or preventive measures are under consideration.

REMEDIAL MEASURES FOR CANKER.

Considerable attention has been called to the methods used in combating this disease by officers of the Imperial Department of Agriculture and others, and therefore it is only necessary to summarize those which have proved most successful.

REMOVAL OF DEAD TREES AND BRANCHES.

All trees or branches killed by canker should be cut out and burned. It is preferable that they should be burned on the spot if practicable, but if not, they should be removed to some heap to be burned. Suckers would appear to suffer little from this disease and therefore it is often practicable to save suckers when a badly diseased tree is cut down, rather than have to wait for the growth of supplies.

EXCISION OF CANKERED AREAS.

When canker spots are detected on the trees, the diseased bark and wood should be cut out with

a sharp pruning knife, care being taken to remove at least a ½ inch of healthy bark around the diseased area. If the affected areas extend for a considerable distance around the stem of the tree, the bark must be removed in stages, or otherwise practically ring-barking may take place. It has been found that the bark from about a third of the circumference of a tree can be removed without seriously affecting nutrition, and after about three or four months, more bark may be removed. Thus the gradual removal of diseased bark from almost the whole circumference of the tree may be accomplished.

The treated trees should be inspected periodically and further, careful search for canker spots made. This part of the work will be greatly facilitated if a ring of white-wash or white paint is put around one of the branches of all trees that have had canker areas removed from them.

The diseased portions that have been cut out should all carefully be collected and burned. They should, on no account, be allowed to remain on the ground at the foot of the tree, for disease may spread from them into the basal portion of the stem.

TREATMENT OF WOUNDS.

The wounds caused by cutting out the diseased tissues should be cleaned and thoroughly treated with tar. It has been recommended that a mixture of resin oil and manjak may be found to be a good substitute for tar. With this mixture, this Department has as yet had no experience, and therefore continues to recommend tar for application to wounds—a substance, when applied carefully and not

allowed to run all down the bark of the stem or branches, that has given satisfactory results. After a tree has been treated, it should be marked by a ring of white-wash or white paint around one of the branches in order that it may be kept under careful supervision.

DISINFECTION OF TOOLS USED IN CANKER EXCISION WORK.

All knives or cutlasses used for cutting out diseased tissues should not be used for pruning purposes, and it is advisable that they should be disinfected before they are put aside.

BEST TIME FOR CANKER EXCISION WORK.

The best time for canker work would appear to be during the dry season, for immediately after a shower the affected areas may easily be detected. Further, the wounds appear to heal more rapidly. It should, however, be mentioned that this work is not to be necessarily limited to the dry season, but should be carried on throughout the year, particularly on those properties where canker is at all prevalent.

RESULTS OBTAINED.

Experience has shown that the above remedial measures will satisfactorily reduce the quantity of canker, if not entirely eradicate it. Estates, on which carefully conducted measures against canker have been carried out, have given increased crops, and the number of cases of canker has been very largely reduced. The beneficial results obtained by the adoption of remedial measures have repeatedly been noticed on various estates in the West Indies,

and although accurate figures are not yet available, yet those from the Experiment Stations in Ceylon, where somewhat similar measures have been practised, show conclusively that attacks of this disease may be rapidly reduced to a minimum.

PREVENTIVE MEASURES AGAINST CANKER.

ATTENTION TO WOUNDS.

In considering preventive measures, it must be borne in mind that the fungi associated with canker are regarded as wound parasites, and therefore one of the first duties on the estate must be the careful attention to all wounds. Cuts made in pruning should be smooth and close to the stem or branch, and should be tarred over, and it may also be found possible that those made while picking can be similarly treated. A joint of bamboo, filled with tar, corked at the top end, and with a small spigot hole just above the lower node to allow tar to drain on the frayed lower end, has been found to be a convenient form by which tar may be carried when pruning operations are being carried on. It may be carried in the left hand, and after a branch or a sucker has been removed, tar can immediately be rubbed on. This dispenses with the carrying of tins, does not allow of tar being put on to such an extent as to drain down the bark from the wound, and saves considerable time.

ATTENTION TO SHADE.

Canker is generally worse in plantations that are too densely shaded, for the condition of moisture

and of semi-darkness assists in the development of the fungi and in the dispersal of their spores.

The reduction of dense shade in order to let in more sunlight is strongly to be recommended where disease is prevalent, for it has been found in Ceylon and in other places that this is a matter that should receive first attention.

It is possible that the judicious thinning out of shade should receive attention on many West Indian plantations, but it must be adopted cautiously, for it has been observed that the direct rays of the sun, in some dry localities, have the power of splitting the cacao bark and of causing wounds to which fungus spores may at a later date gain entrance. Reduction of shade should be done cautiously, and the effect closely watched before it is attempted upon a large scale.

EXPERIMENTS WITH SPRAYING.

It has been recommended that spraying should be adopted throughout cacao orchards to destroy fungus spores with a view to preventing infection, but experimental evidence as to the economy of such a practice for the spores of the fungi causing canker is yet to be forthcoming. Favourable results have been obtained in some orchards in temperate climates from spraying for canker of fruit trees, but no conclusive evidence has yet been obtained in tropical countries.

DIE-BACK.

This disease of cacao was investigated by Howard in Grenada and has subsequently received attention in St. Lucia and Dominica. In St. Lucia it was at one time particularly common, where it probably is the most serious of fungus diseases. It was very prevalent at low elevations on the light soils in the vicinity of sugar-cane cultivation, but can be entirely eradicated from a plantation by high cultivation and the general adoption of sanitary methods. A few cases have been noticed in St. Vincent. A similar disease, caused by the same fungus, has recently been reported by Petch from Ceylon, but does not appear to be very common.

Specimens of the fungus responsible for this disease were forwarded by Howard to Kew, where it was determined by Massee as *Diplodia cacaoicola*, P. Henn., a form reported on dead cacao branches in the Cameroons. This fungus is extremely common on diseased branches and twigs and is also found on cacao pods. Van Hall in Surinam reports a species of *Chaetodiplodia* on diseased cacao twigs, and it is possible that a similar fungus may be found to be associated with *Diplodia* in some of the West India Islands.

SYMPTOMS OF DIE-BACK.

The disease commences in the younger twigs and spreads from them to the larger branches. The trees on which the young twigs have been killed, present an appearance that is known as 'stag-headed.'

Sometimes cacao trees die back to a slight extent at the extremities of the branches through poverty of soil, wind, drought, etc., but in such cases there is always a sharp line of demarcation between the dead and living tissues. If, however, twigs that have been killed by the 'die-back' fungus are cut longitudinally, there is no boundary line between the living and dead tissues. The ends of the twigs are black and quite dead, and then an intermediate brownish-coloured zone is noticed between the dead and living tissues. Microscopic examination reveals fungal hyphae in this transition zone, which are at first colourless and then brownish.

FRUCTIFICATIONS OF DIE-BACK FUNGUS.

In the rainy season, or even after a good shower, small blackish pustules will be observed to break through the bark. From these, the spores of the fungus may be obtained.

The life-history of *Diplodia cacaoicola* was worked out by Howard, who found that this fungus was parasitic on sugar-cane and on cacao in these colonies. The fungus is a facultative parasite and can live upon dead cacao wood, shells of cacao pods, and upon sugar-cane. The spores are produced in pycnidia just beneath the epidermis. They are at first unicellular, and colourless or faintly greyish, but subsequently they become two-celled and dark-coloured.

The colourless spores have been found in the laboratory to germinate more readily than the bi-cellular, dark-coloured, mature ones.

SPREAD OF DIE-BACK.

Infection experiments conducted by Howard in Grenada point to this fungus being a wound parasite and capable of seriously affecting trees not in a vigorous condition.

The spores are spread by means of wind and rain, and it is only necessary for a wound to be present for infection readily to take place.

It has frequently been noticed that bad attacks of thrips and outbreaks of die-back disease frequently go hand in hand. Whether the thrips may make wounds through which the fungus can gain an entrance has yet to be demonstrated. This is a matter that should receive investigation.

REMEDIAL MEASURES FOR DIE-BACK.

HIGH CULTIVATION.

This disease does not readily attack trees in a vigorous condition of growth. Every effort should, therefore, be made to improve the vigour of the trees by thorough cultivation. All diseased branches and twigs should be cut out and burned, and all wounds thus made should be followed by an application of coal tar or some similar substance.

It has been demonstrated in St. Lucia, by the work on the Experiment Plot at La Perle estate, Soufrière, that this disease may be defeated by high cultivation, manuring, and attention to careful pruning. The disease has practically been eradicated from this estate, and it is reported by Hudson that the yield of cacao has been increased from practically

nothing to over 1,000 lb. of cured cacao per acre, within six years. This fungus is not very destructive to carefully cultivated vigorous trees, so every effort should be made to improve the condition of all unhealthy trees.

Pen manures and mulchings should be applied, and all weeds carefully buried.

Protection from wind should be carefully looked to. It has been found in some localities in St. Lucia that shading with bois immortel has been productive of some good on estates suffering from this disease.

DESTRUCTION OF DISEASED TISSUES AND BURIAL OF HUSKS.

All dead wood and twigs must be cut out of the plantation and burned. The cuts should be tarred.

It is also important that the husks or shells of all cacao pods should be buried with lime, for it has been shown that heaps of old pods lying unburied about a plantation serve as centres of infection for the spread of disease.

It has been suggested that cacao shells may be treated with lime on the surface, but it would be preferable that they be buried, for experience has shown that such a procedure is the most sure and the most economical of all the various methods that have been experimented with in checking the spread of the fungus that is responsible for this disease, and for the 'brown pod' rot.

LASIODIPLODIA.

Towards the end of 1906, diseased specimens of roots and stems of cacao were forwarded to this Department from a southern district of Trinidad for examination. It was found on examination that large numbers of septate, dark-coloured mycelial threads were present in the vessels of the roots, and in the vessels, medullary rays, and other cells of the stems. Fructifications were obtained in the laboratory, and the fungus was provisionally identified as a species of *Lasiodiplodia*. Specimens were then forwarded to the United States Department of Agriculture for confirmation of identification, with the inquiry as to the similarity between the Trinidad fungus and one under investigation by that Department from San Domingo and Brazil. The fungus on the stem was referred to the species of *Lasiodiplodia* reported as attacking cacao and mangos in Brazil and San Domingo but decision as to the identity of the fungus in the roots was reserved until development of cultures could render its recognition possible.

OCCURRENCE OF LASIODIPLODIA.

Further investigation in the laboratories of this Department has shown that the fructifications from the fungal hyphae in the roots appear to be identical with those procured from the stem, and it is more than probable that they were continuous throughout the tissues of the diseased trees.

This fungus was subsequently found on old cankered areas on trees in Grenada, and quite re-

cently on diseased trees from several districts in Dominica. Barrett, while investigating the cacao diseases of Trinidad concluded that practically the whole of the disease in cacao plantation is due to a species of *Lasiodiplodia*, for it infects the fruits, the branches, and the stems by means of wounds, and by means of the cushions from which the fruit-stems arise.

Our experience with this fungus has not been sufficiently lengthy to allow of investigations into the complete life-history to be carried out, and it has not yet been definitely established how infection may take place. Infection experiments carried on at Dominica showed that the fungus is weakly parasitic in habit, and, therefore, it may be supposed that infection might take place through wounds. Whether infection of the roots may also take place, has yet to be established. In Trinidad, it was supposed that the fungus spreads rapidly in the tissues, and consequently the disease kills off trees rapidly ; but experience in Dominica would indicate that the course of growth of the fungus is slow, for trees may be affected for a considerable time before they are killed out. High cultivation and careful manuring have been beneficial in Dominica, but the fungus is generally to be found in districts where the soil is not particularly suited for the growth of cacao.

In Grenada, the fungus was obviously associated with canker, and appeared to be following old areas affected previously with *Nectria*. In Trinidad, canker is attributed to this fungus, as also is a disease of pods,

PRESENCE ON PODS.

A scabby appearance of pods, in which small, blackish, corky patches are developed on the surface at intervals, has been observed in Grenada, and a similar appearance of pods has been found in certain parts of Dominica. The pods do not grow to quite the full size, but generally do not decay. The beans are often small and undeveloped. When such pods are placed in a damp chamber they invariably develop the fungus *Lasiodiplodia*, but it does not appear to have occasioned much damage.

REMEDIAL MEASURES FOR LASIODIPLODIA.

Until further information has been gained of this fungus, definite remedial measures cannot satisfactorily be indicated. Where trees are affected, as in Dominica, and present a dwarfed invigorous appearance with dying back of branches, and dark-black fructifications pushing through the bark, they should receive high cultivation, careful drainage, and manuring. Where the fungus affects the bark and produces a 'cankered' appearance, resource should be had to the remedial measures indicated above for the typical canker disease of the stem.

PINK DISEASE.

This disease was first noticed in certain localities of Dominica in 1906, but it has subsequently been found on some estates in St. Lucia. It does not at present appear to be of a very serious character and can satisfactorily be kept in check.

SYMPTOMS OF PINK DISEASE.

The smaller woody branches of cacao frequently become covered with a pinkish incrustation of adpressed fungal hyphae. This, in younger branches, spreads all over the surface, while in the older branches it is usually to be found only on the surface of damper and more shaded sides.

Fungal threads from this pinkish mass push into the tissues of the bark, and may sometimes in small branches penetrate into the deeper tissues of the wood. The bark eventually cracks and splits, and then peels off. Generally it has been found that new bark has been formed, and it is not often that branches are killed off through fungal hyphae penetrating into the deeper tissues.

THE ORGANISM THAT CAUSES PINK DISEASE.

The fungus (*Corticium lilaco-fuscum*) that causes this disease is the more noticeable in damp, shaded situations, and during the rainy season, but cracked bark, showing where the branches have been attacked, is easily recognized during the dry portion of the year. The fungus may spread all over the surface of a branch and to other branches.

THE EFFECTS OF THE FUNGUS.

The chief danger of this fungus would appear to be that it causes cracks in the bark of the affected branches that serve as wounds for the entrance of spores of *Nectria*, *Diplodia*, etc, and, therefore, unless it is kept in hand, it may be the means of assisting the rapid spread of diseases throughout the plantation.

REMEDIAL MEASURES FOR PINK DISEASE.

The fungus may be destroyed by washing the affected branches with a lime-sulphur wash. This may be made by mixing 7½ lb. of slaked lime with 2½ lb. of flowers of sulphur in 10 gallons of water, and boiling until the mixture turns orange in colour. When cold this mixture should be well rubbed on the parts of the branches affected.

All the younger branches that have been killed out should be cut off and burned, and even some of the larger ones it might be advisable to remove.

THREAD BLIGHTS.

Thread blights on cacao were first found in St. Lucia in 1904, and were described by Lewton-Brain at the fifth Agricultural Conference held at Trinidad in 1905. They have subsequently been found in Trinidad, Dominica, Tobago, and British Guiana. During last year, several different thread blights on a variety of plants were forwarded for examination to this Department from Trinidad. These were carefully investigated.

SYMPTOMS OF THREAD BLIGHTS.

Thread fungi generally consist of sterile mycelial threads or strands of various colours running irregularly up and down on branches and stems, and closely adpressed to the bark. The delicate strands of mycelium sometimes form swellings before branching takes place. They generally spread upwards over all the younger twigs and buds, and then not unfrequently pass to the leaves, and appear on their under surfaces in the form of a network of fine filaments. Where two leaves touch, these filaments spread from one to the other, sometimes forming a thickened cushion at the point of contact.

MICROSCOPIC EXAMINATION.

Microscopic examination of these mycelial strands shows that they are composed of parallel-running fungal hyphae closely woven together. From the underside of these strands, numerous hyphae are given off into the bark of the twigs, and in the case of young twigs they penetrate through the cortex into the deeper tissues thus causing the death of the attacked portions. Similar hyphae also penetrate from the strands on the under surface of the leaves into the deeper tissues and also into the tissues of buds. Leaves and buds may, therefore, also be killed by the fungus.

Specimens of different thread fungi have been carefully examined, and it has been found that the mycelial threads are not composed of similar hyphae. It is extremely probable, therefore, that these thread blights do not represent the same fungus in all cases.

Fructifications have not yet been obtained, but it is possible that some of them belong to the Basidiomycetes, for clamp-connexions have frequently been observed.

HORSE HAIR BLIGHT.

'Horse hair blight' resembles closely a tuft of horse hair caught in the twigs. Some of the threads are closely attached to the bark, and send in hyphae into the deeper tissues of the branches. Specimens of horse hair blight have recently been sent by Hart from Trinidad to Kew for identification. The fungus was determined as *Marasmius equicrinus*, Mull.

SPREAD OF THREAD BLIGHTS.

The chief method of spread is by means of the threads on dead twigs, leaves, etc., being blown or caught in the branches of healthy trees. In India, thread blights have been spread from jungal trees on to tea, while in Ceylon similar diseases are known on nutmegs and tea. In Java they have been found upon coffee.

REMEDIAL MEASURES FOR THREAD BLIGHTS.

Thorough and constant pruning and burning of all diseased material appear to have kept the disease in check in St. Lucia. It is still occasionally found in damp, shaded portions of plantations, but does not threaten to be a serious disease. All wild trees near cacao plantations that are affected with thread blights should be pruned back, so as to avoid the danger of spread of the disease from them to the cacao, and shade should sometimes be reduced. Applications of lime and sulphur wash, as recom-

mended for 'pink disease,' to the fungal threads are also recommended, where heavy prunings cannot satisfactorily be given.

WITCH BROOM DISEASE.

This disease has proved most serious in the cacao plantations of Surinam and has been under most careful investigation by the agricultural authorities there. It has recently been reported from one or two localities in British Guiana, and has been found in a single instance in Trinidad.

SYMPTOMS OF WITCH BROOM DISEASE.

The symptoms are well defined. The twigs are affected in the bud state. Hypertrophied growth takes place and there is a tendency towards making many side branches, and producing clusters of twigs resembling brooms. The fruits are also affected by the fungus. When young, they often show a small swelling on one side, which frequently may be rather difficult to detect except by the trained eye. At other times simply a discoloured spot is noticed, which later, as the tissues die, becomes black. The pods do not grow to a normal size, but become excessively hard. This symptom the planters call *petrification*, and affected pods may easily be distinguished from pods attacked by other diseases.

THE ORGANISM THAT CAUSES WITCH BROOM DISEASE.

The fungus responsible for this disease was described as *Exoascus theobromae*, Ritz Bos, but the characteristic fructifications of this fungus are

extremely difficult to find. It has however been shown that the witch broom of the twigs is caused by the same fungus as the *petrification* of the fruits.

REMEDIAL MEASURES FOR WITCH BROOM DISEASE.

The disease has done a considerable amount of damage in Surinam, and efforts have been made to find measures of control. A heavy pruning of all infected trees and spraying with Bordeaux mixture have been given a careful trial, and some encouraging results have been obtained. If the experiments continue to be successful, they may lead to important conclusions towards solving a problem of great moment to that country.

This disease has not yet made its appearance in any of the West India Islands, and every effort should be made strictly to enforce the Plant Protection Acts that have, within the last few years, been passed to prevent the spread of diseases throughout these colonies.

BROWN ROT OF PODS.

This disease occurs in all cacao-growing districts of the West Indies. It was first investigated by Howard in 1901 in Grenada, and has been noted in St. Lucia, Dominica, St. Vincent, and British Guiana. In some instances, particularly when weather conditions were favourable for the spread of the fungus, it has occasioned considerable damage, but it has been demonstrated that properly conducted preventive and remedial measures will easily keep this disease in check.

SYMPTOMS OF BROWN ROT.

The brown rot of cacao pods is caused by *Diplodia cacaoicola*—the same fungus as the die-back disease of the stem. The disease commences as a small, brown, almost circular spot at either end of the pod or along one of the grooves. It is most commonly seen to commence from the basal end of the pod attached to the tree. This brown decay spreads rapidly all over the pod destroying the rind. Subsequently it spreads into the centre of the pod and destroys the cacao beans, which are enveloped by a greyish-brown mass of fungal mycelium. The pods usually become soft and rotten, and eventually fall from the trees. Diseased pods are generally the more common near the 'breaking places' particularly on those estates on which burial of husks or shells is not generally practised.

FRUCTIFICATIONS OF FUNGUS.

From the brownish-coloured diseased areas small pustules may be seen bursting through the rind of the pods, and emitting a greyish-white powder. These are the unicellular, colourless spores of *Diplodia cacaoicola* and subsequently they become bi-cellular and dark brownish-black in colour. The whole pod eventually becomes black from the mature spores given off from the numerous pustules.

Investigation has shown that this fungus on the pods is identical with the one that causes die-back of the stem, and infection experiments carried out by Howard, and subsequently repeated, show that it is

parasitic in habit. The fungus is frequently found upon old cacao husks, and therefore is grouped with the facultative parasites.

REMEDIAL MEASURES FOR BROWN ROT.

BURIAL OF DISEASED PODS AND OF HUSKS.

This disease may readily be kept in check by collecting all diseased pods and burying them, together with all husks and shells, with lime in trenches or pits. Ripe pods that show the brownish diseased areas should at once be picked in order to save as many of the beans as possible.

Experience in most of the West India Islands has shown that the burial of husks and diseased pods is a means of checking the disease, and owners of estates that have followed this practice will testify to the considerable reduction in diseased pods. Some estates in Grenada and St. Lucia have greatly reduced their losses by adopting the above measures.

It has been suggested that treatment of shell heaps with lime on the surface might be equally effective, but direct evidence on this point has yet to be obtained. It is doubtful, however, whether such a system could be as strongly recommended as burial.

DENSE SHADE AND BROWN ROT.

This disease is still very common in several parts of the West Indies, and is generally to be found in damp, shaded situations. It is possible that some reduction of overhead shade may, in some instances, be productive of beneficial results.

SPRAYING.

An epidemic of the disease could be checked by spraying the pods on the trees of a plantation with Bordeaux mixture, after the most badly diseased ones have been removed. Spraying for pod diseases has been experimented with by Wright at the Experiment Stations in Ceylon, and it was found that the number of fungus-attacked pods could considerably be reduced by systematic spraying, and that the increase in the crops showed considerable profit above the expenditure incurred by the operations. It was stated, however, that the results of different experiments showed that spraying could only be advised for the fruits, and should be carried out at the setting of the young fruits or during crop time.

BLACK ROT OF PODS.

This disease is common in Trinidad but has also been found at St. Lucia, St. Vincent, and British Guiana.

Attention was first called to it by Hart in 1898, when it was found that a larger percentage of the crops in many districts in Trinidad were being destroyed. Investigations by the Botanic Department of Trinidad, and by Kew showed that the disease was due to the fungus *Phythophthora omnivora*, De Bary.

SYMPTOMS OF BLACK ROT.

The attacked pods turn black and are then covered with the white mycelium of the fungus which produces larger numbers of ovate conidia. These may be carried by rain or wind to other pods, and if conditions are suitable, they may germinate at once, penetrate the tissues and further produce the disease. The mycelium of the fungus spreads rapidly in the substance of the pod, and resting spores (oospores) are formed by a sexual process—thereby enabling the fungus satisfactorily to tide over periods that may be unfavourable for its growth. These oospores are liberated on the decay of the fruit, when they germinate and start the disease again.

The pods affected by this disease usually assume a dense black colour, become hard, and often hang, covered in places with white fungal mycelium and conidia, on the branches for a considerable period before they fall.

REMEDIAL MEASURES FOR BLACK ROT.

BURIAL OF DISEASED PODS AND OF HUSKS.

Diseased pods should all be collected and buried with lime in order to destroy the superficial conidia and the deep-seated oospores of the fungus.

It is advisable also that all husks and shells, as recommended in the remedial measures given for the 'brown pod rot,' should be buried with lime.

DENSE SHADE AND BLACK ROT.

A reduction of shade might be practised in some localities, for too moist and shaded a situation favours the growth of the fungus and the spread of the disease.

SPRAYING.

In epidemics, spraying with Bordeaux mixture should be resorted to, and on those estates where this disease is generally prevalent, carefully conducted experiments to ascertain how much disease may be prevented by periodic and systematic sprayings should be carried out.

RESULTS OF REMEDIAL MEASURES.

The adoption of the removal of all diseased pods and burial together with husks with lime has been general on many Trinidad estates, and the extent of the disease has been considerably reduced.

SCABBY POD.

Cacao pods showing small, irregular, brownish-black corky areas produced at intervals all over their surfaces have on several occasions recently been forwarded to this Department from Grenada. Others have also been found in Dominica. These pods do not grow to full size and the quality of the beans is poor.

Microscopic examination of these corky areas showed the mycelium of a fungus beneath them, but it could not be ascertained whether this mycelium extended to any considerable depth in the tissues. On placing the pods, however, in a damp chamber, fructifications of a species of *Lasiodiplodia* always made their appearance and, therefore, this peculiar condition of the pods will receive further attention.

Further investigation will be conducted into the nature of this disease, and its economic importance endeavoured to be ascertained. At present, however, it does not appear to be very common, nor does it seem to occasion much damage.

NECTRIA ON PODS.

In 1898, Hart sent from Trinidad pods affected by *Nectria Bainii* to Kew for examination. This supposedly parasitic fungus does not appear to be very common. It causes 'semicircular dark blotches to appear on the pods, the diseased portion becoming soft and watery.' Later these become covered with a yellowish and orange-coloured mycelium, from which are given off small red perithecia.

During investigations in Dominica, St. Lucia, and St. Vincent, species of *Nectria* were very rarely found upon living cacao pods and these did not always belong to the same species. A further investigation into the life-history of this fungus and into its distribution, as well as of other species of *Nectria* found on cacao, will have to be carried out before it can definitely be stated whether *Nectria Bainii* is of great economic importance.

The measures recommended for the control of the brown or the black rots of pods would probably be effective in keeping any outbreak of this fungus in check.

SANITATION OF CACAO ORCHARDS.

Having given descriptions of the several fungus diseases of cacao in the West Indies, it is here intended to indicate as briefly as possible the principal points for consideration towards maintaining the health of the trees and preventing disease.

A considerable amount of knowledge of the life-histories of many of the fungi parasitic on cacao has been gained during the past few years, and efforts have been made to fight the different diseases. In many cases, however, further inquiry into the life-histories of the fungi under consideration is still necessary, in order to ascertain when the direct remedial measures may be employed with the best prospect of success. Additional investigations will have to be made in order to elucidate clearly the relations that exist between the various parasites and the cacao tree. Further study must also be made of the remedial measures against these diseases in order to assure that the most direct and economical methods are being adopted. Subsequently, a thorough scientific investigation of the different species of the fungi on cacao—saprophytic as well as parasitic—will have to receive attention.

THOROUGH CULTIVATION.

If the remedial measures given above for the various diseases are carefully studied, it will be observed that it is recommended that considerable

attention should be given to careful and thorough cultivation. Results obtained on the experiment plots of the Imperial Department of Agriculture, established in the various West India Islands, have shown that high cultivation and judicious manuring are followed by the best returns. Expenditure on tillage, drainage, and manures is followed by increased profits, and the vigour and health of the trees are improved.

THE HUMUS QUESTION.

For the supply of humus for cacao estates it may be found necessary in some localities in these colonies to set aside areas on the estates for the growing of grasses, or leguminous crops that may be used in the plantations either as mulch or in the form of pen manure.

It has frequently been observed by scientific workers in other countries that when conditions of soil or climate are such as to interfere with vigorous and healthy growth, changes may take place in the tissues of the host plant which may favour the development of the fungus and enable it to do considerable damage with great rapidity. Healthy development may, on the other hand, assist the plant in resisting attacks of fungi or making their inroads unimportant.

Pen manures have been found to be especially valuable, and the healthy vigorous condition of trees after the adoption of mulching, and the judicious use of weeds both in Dominica and in St. Lucia can but recommend this practice for consideration at the hands of cacao planters.

PRUNING, AND EXCISION OF CANKERED AREAS.

Careful attention should be given to pruning, and to canker excision. Several of the fungi of the cacao tree are wound parasites, and therefore it is necessary that all wounds whether made by pruning, or caused accidentally, should be looked after. In pruning, it is necessary that the cuts should be as near the main trunk or branch as possible. They should be smoothed off with the pruning knife and should all be coated, as soon after the cuts are made as possible, with an application of tar, paint, resin oil and manjak, or some similar mixture. Tar has been largely used in the West India Islands and has proved generally satisfactory. Care must be taken, however, that it is not allowed to be smeared down the bark of the trees, for it appears to have some injurious effect upon it and upon the flower shoots that are given out. When confined to the cut surface of the wound, it answers well, especially if applied during the dry season. Canker excision for this reason, as well as for several others -such as ease of detection of cankered areas, less active flow of sap, and greater rapidity of the healing of the wounds—should be carried out preferably during the dry months. This important work, however, should not necessarily be confined to this period, particularly on estates where the disease is prevalent.

CARE DURING PICKING.

Care should also be exercised during picking, for many of the wounds made during this operation, particularly by the cacao hook, have been sufficient for canker to commence in.

SUCKERS.

All suckers, except where they are needed for use in shaping the tree or for replacing it, should be removed periodically and the cuts tarred. It has been experienced in Ceylon and also in the West Indies that suckers are sometimes less liable to canker than old trees, and therefore it is often possible to save a sucker or two from the basal portion of the tree to take the place of the diseased tree when it is removed. The adoption of this plan makes it possible frequently to replace a diseased tree in a shorter time than would be required by the growth of young supply plants.

TREATMENT OF WOUNDS.

Wounds caused by the falling of portions of shade trees or of bananas and plantains should always receive immediate attention, and all the injured branches should be removed. The wild plantains, such as the cokoi of Dominica, appear to suffer less from wind than the cultivated varieties, and are useful in the establishment of young cacao cultivations.

REMOVAL OF DEAD BRANCHES.

Dead branches caused by the falling of trees or plantains above referred to, and all branches killed out by either die-back, canker, or root disease should be cut out, removed from the plantation, and burned. Many of the fungi of cacao are facultative parasites and can live and increase upon these dead branches

and twigs if they are allowed to remain on the estate. Diseased bark, excised when treating canker, should also be collected and burned. It should never be allowed to remain at the base of the tree from which it has been cut.

BURIAL AND TREATMENT OF ALL DISEASED PODS, AND OF HUSKS AFTER BREAKING.

All diseased pods, and husks of pods after they have been broken, should be collected and buried in pits or trenches with lime. It has been found that such procedure is productive of the best results, and should be adopted until experimental evidence is forthcoming as to the value of the suggested treatment of such pods and husks upon the surface of the soil.

PROTECTION FROM WIND.

Cacao should always be protected from wind. Wind-swept orchards suffer more from disease than do well protected ones. The trees are not so vigorous. Nor do they bear so heavily. Wind belts should be established throughout plantations where necessary. Pois-doux and galba are useful for this purpose, but in some cases overhead shade of bois immortel is relied upon for protection from wind.

SHADE.

In St. Lucia, several instances of shading with bois immortel have been productive of much good on estates suffering from 'die-back,' but it must also be recorded that in several localities in some of these

islands some reduction of shade might judiciously be made. A moist atmosphere and densely shaded conditions are extremely favourable for the development and spread of fungi, and it has frequently been found in some parts of Dominica and St. Lucia that the gradual removal of shade trees, or of some of their branches, has served as a factor in the control of canker. In Ceylon, the letting in of sunlight is strongly recommended, but it is necessary in the West Indies that it should be adopted cautiously, until experimental evidence is forthcoming, for quite a number of factors have to be taken into consideration. In Trinidad, however, it was observed in 1906, that canker was less prevalent in lightly-shaded cacao than in plantations very densely covered.

TREATMENT OF ROOT DISEASE.

Where cacao trees, pois-doux or other trees in the orchards die from root disease, they should immediately be removed and burned. The roots should be extracted, and burned with the stems and branches. Trenches should be dug around the affected areas, and large applications of quick lime should be given. The fungicidal properties of quick lime have yet to be fully appreciated, and the use of this substance is valuable in the control of the root disease. Drainage should also be attended to, for root disease has been noticed to be generally worse on water-logged, low-lying soils.

OTHER TREES AFFECTED BY ROOT DISEASE.

The susceptibility of bread-fruit, bread nut, and certain other trees to attacks of the fungus

responsible for root disease of cacao would suggest that these trees should be excluded from all new plantations of cacao. In those plantations where they are at present growing, they should be carefully watched, and when showing any signs of disease should be taken out and burned. When it is thought desirable, at any time, to cut down any of these trees, particular care should be taken thoroughly to extract as many roots as possible, and to destroy them by burning.

SPRAYING FOR POD DISEASES.

Spraying for pod diseases has been experimented with in Ceylon and the results warrant experiments being conducted on West Indian estates as a means in the prevention of similar diseases. A good trial should be given, and accurate figures of the increased expenditure incurred in carrying on such operations, and of the increased crops should be kept for a series of years. Definite information as to the value of spraying for prevention of pod diseases would then be available, and would indicate whether such operations should be generally adopted as routine estate practices.

CONCLUSION.

In conclusion, it should be added that considerable information in respect to diseases is available for the cacao planter, and trials of remedial measures have shown that they are all practically amenable to treatment. Further investigations are in hand and it is expected that additional knowledge

of the different fungi will shortly be forthcoming. It should be pointed out, however, that the mycologist must, for the present, occupy more or less the position of the 'specialist,' while the various agricultural instructors and the planters themselves must be the 'general practitioners.' They should adapt the suggestions for remedial measures to suit loca conditions, and they may render valuable service to an important section of West Indian agriculture by recording accurate observations on diseases and their treatment, for the information and guidance of Agricultural Authorities.

APPENDIX.

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